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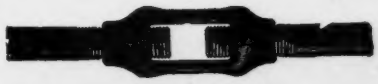

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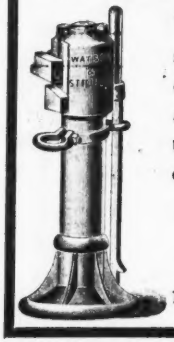

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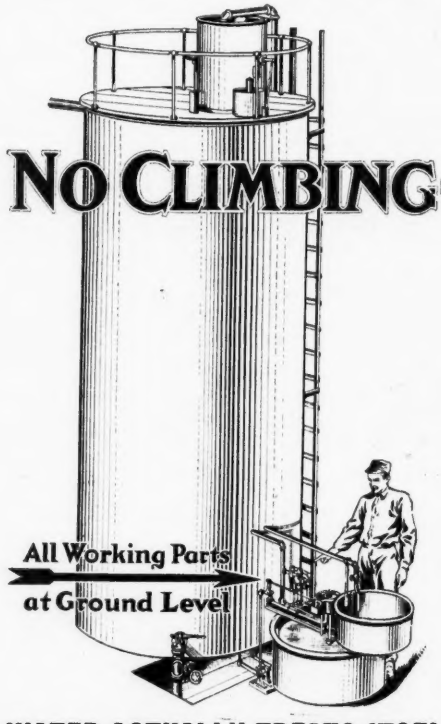

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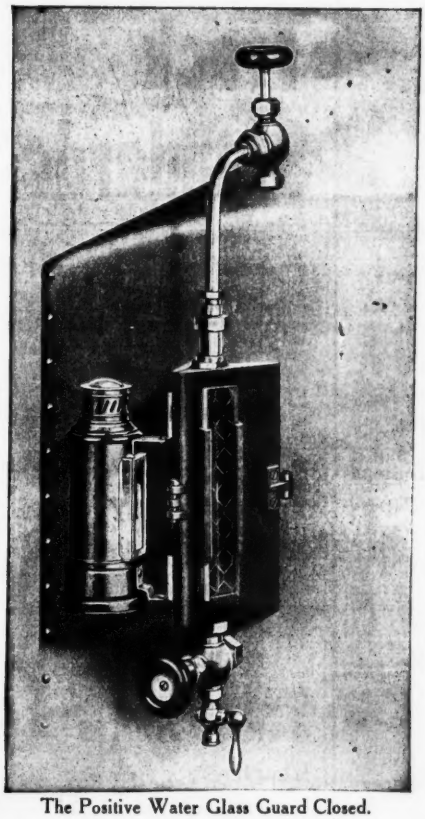

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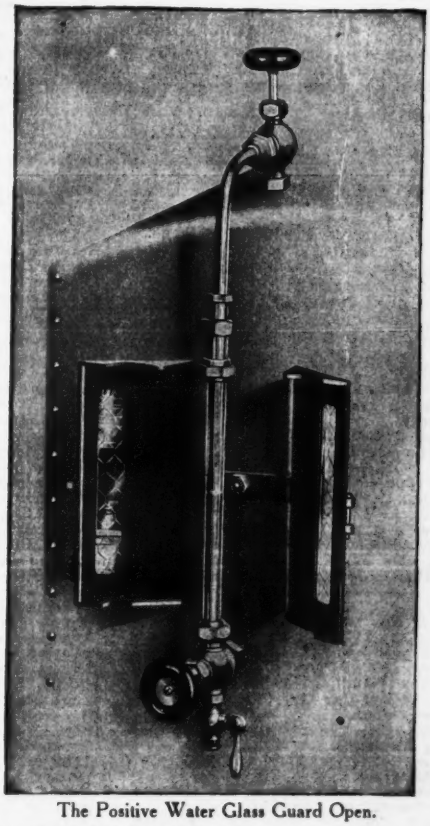

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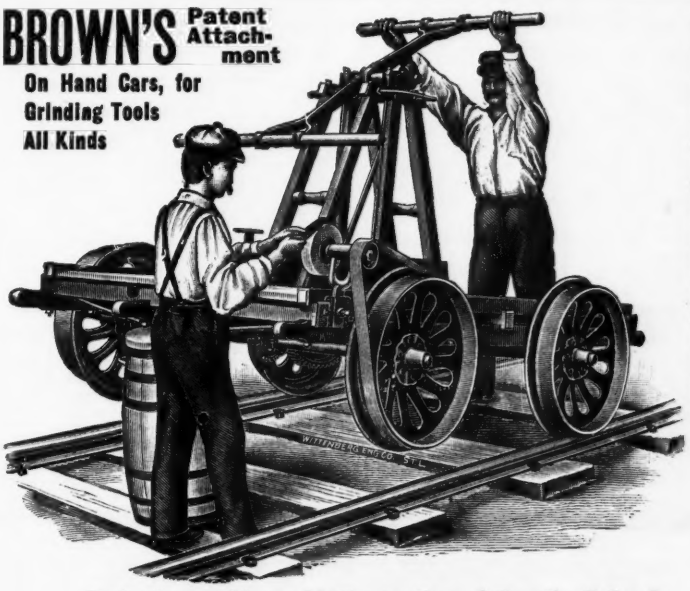

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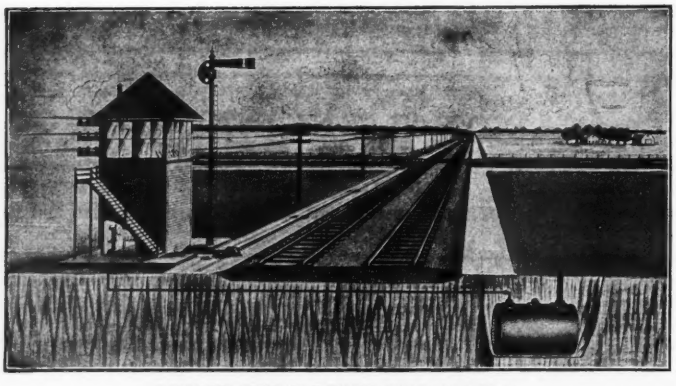

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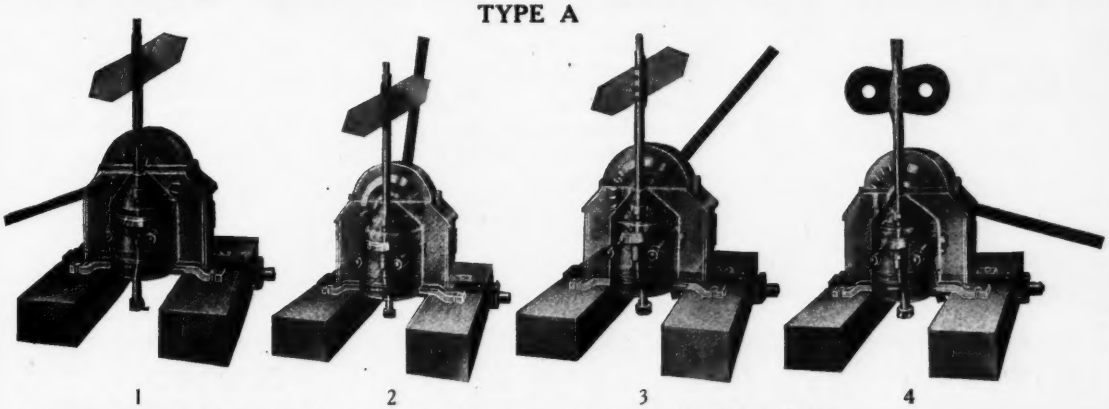

1 2 3 4

1. **ONE MOVEMENT OF ONE LEVER PERFORMS THREE OPERATIONS.**
2. Moving the lever from 1 to 2 closes the switch; from 2 to 3 interlocks points; from 3 to 4 clears home and distant signals.
3. Moving lever from 4 to 3 sets home and distant signals to danger; from 3 to 2 withdraws interlock; from 2 to 1 opens switch.
4. **EASY AND SIMPLE TO OPERATE.**
5. While all operations are accomplished with one lever it only requires power enough for one operation at a time.
6. Each gear remains locked except when performing its function, and each operation must be completed before the next is possible.
7. **SIGNALS CANNOT BE CLEARED UNLESS POINTS ARE INTERLOCKED FOR MAIN LINE.**
8. If point does not come up to stock rail, plunger will not enter lock bar and lever will stop between 2 and 3.
9. All stands are provided with chain sheave to connect with distant signal.
10. Switch crank throws 180 degrees and locks on dead center. Pressure on the points will not throw the lever over.
11. When the lever is down on either side all gears are out of mesh and locked on driving gear.
12. The strain on wires from distant signal will not turn the lever as teeth do not engage till lever is raised above latch.
13. **DOUBLE PROTECTION FOR SWITCH POINTS. TWO INDEPENDENT CONNECTIONS FROM POINTS TO TIES.**
14. Connecting rod and lock bar connect with points independently providing against defective switch connections.
15. The interlock is spiked to ties before stand is set and the stand will lift off without disturbing the interlock.
16. If interlock connection is made below top of ties it holds point safe if switch connection is defective or destroyed.
17. **EASY AND SIMPLE TO INSTALL.**
18. Notch ties and spike interlock in position located according to length of connecting rod.
19. Set stand with feet against steel plate and spike down. Latches are on the housing and need not be spiked separately.
20. **PROTECTION OF DISTANT SIGNAL PROVIDED WITHOUT EXTRA LEVERS TO OPERATE.**
21. To switch cars on main line and keep signals set at danger move the lever between positions 1 and 2.
22. In opening the switch the first movement of the lever sets the signals to danger before the switch is unlocked.
23. If the switch is left open the distant signal is held at danger and protects approaching trains.
24. **A COMPLETE INTERLOCKING UNIT FOR SINGLE FACING POINT SWITCHES.**
25. This stand is especially adapted to outlying facing point switches.
26. It provides interlock and distant signal protection for facing point switches.
27. All operations being under control of one lever it does not require experienced men to operate it.
28. When the lever is moved from one side to the other each operation is completed in its proper order.
29. Each operation has to be properly executed and completed before the next one is possible.
30. Connection from the chain sheave can be made by wire to distant signal, or to pole changer for power signals.
31. Foster interlocking switch stand.
32. Only one lever for all operations.
33. Sent on approval.
34. Tested by a year's service.
35. Easy to install and easy to operate.
36. Reliable and positive mechanism.

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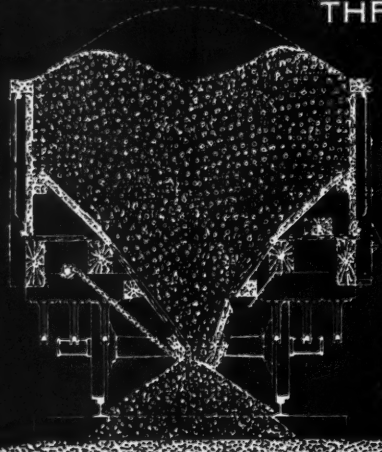

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CAR

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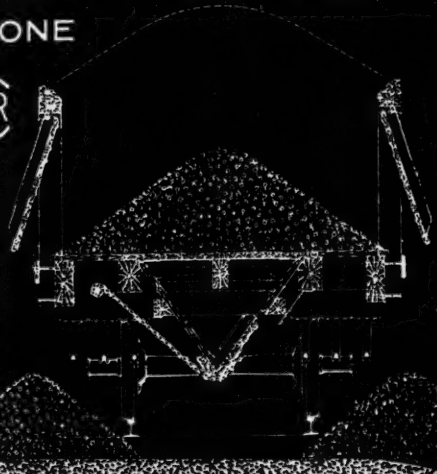

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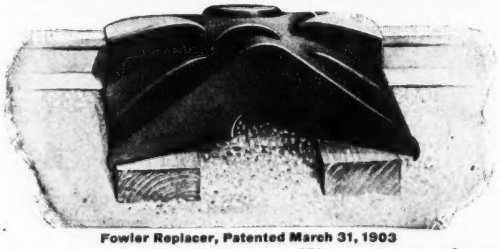

Fowler Replacer, Patented March 31, 1903

A time and money saving device. We can put you on the track

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Railway Engineering

and Maintenance of Way

Mr. S. Shields has been appointed general air brake inspector of the Atlantic Coast Line, with headquarters at Wilmington, N. C.

Mr. D. J. Redding, master mechanic of the Pittsburg & Lake Erie, has been promoted to assistant superintendent of motive power with headquarters at McKees Rocks, Pa. This is a new office and the change is to become effective at once. Mr. Redding is president of the Railway Club of Pittsburg.

Mr. W. L. Allison, mechanical engineer of the Atchison, Topeka & Santa Fe, with office at Chicago, has resigned to accept a position with the Franklin Railway Supply Co., New York City.

Mr. F. B. Shimer has been appointed general storekeeper of the Lehigh Coal & Navigation Co., at Lansford, Pa.

Mr. Gordon Grant, inspecting engineer of the Transcontinental Railway Commission, Canada, has been appointed chief engineer of the Transcontinental Railway, to succed Mr. H. D. Lumsden, resigned.

Mr. R. Neikirk, supervisor of track of the Cleveland, Cincinnati, Chicago & St. Louis at Indianapolis, Ind., has been appointed supervisor of the Indianapolis Union, Indianapolis, Ind., vice Mr. G. W. Rohrman, resigned.

Mr. W. E. Mann has been appointed division engineer of the Grand Trunk Pacific at Edmonton, Alta., vice Mr. R. W. Jones.

Mr. H. C. McCluer has been appointed chief engineer of the Memphis, Paris & Gulf, with office at Nashville, Ark., succeeding Mr. E. La Manna.

Mr. W. F. Sparks, roadmaster of the Forth Worth division of the St. Louis Southwestern, has resigned to accept the position of roadmaster of the St. Louis, Brownsville & Mexico, with headquarters at Kingsville, Tex.

Mr. C. L. Dougherty has been appointed acting mechanical engineer of the Cleveland, Cincinnati, Chicago & St. Louis, with headquarters at Indianapolis, Ind. He succeeds Mr. B. O. Lockwood who resigned recently to take a position with the Pressed Steel Car Co.

Mr. W. M. Scroggins has been appointed general car foreman of the Texas & Pacific at Longview Junction, Tex., in place of Mr. Thomas Welch, who has resigned.

Owing to the illness of Mr. J. W. Petheram, chief engineer of the Missouri, Kansas and Texas R. R. of Texas, Mr. A. M. Acheson, now superintendent of the Trinity division, has been appointed acting chief engineer of the Texas lines. Mr. Acheson will be succeeded as superintendent by Mr. C. H. Huddleston, now a conductor.

Mr. O. H. P. Connell, Winston-Salem, N. C., has been appointed chief engineer of the Winston-Salem South Bound Ry., at Winston-Salem, N. C.

Mr. John P. Dunn, for 37 years with the engineering department of the Philadelphia & Reading, has resigned and will engage in the hotel business at Atlantic City, N. J.

Mr. J. F. Bolleau, supervisor of buildings and bridges of the Iowa Central, has resigned and Mr. S. J. Johnson, bridge foreman at Oskaloosa, Iowa, has been promoted to the vacancy.

Mr. Charles M. Jacobs, consulting engineer of the Pennsylvania R. R. tunnels at New York city, and the man who designed the McAdoo tunnels, left on the Mauretania Aug. 4 for Europe on a vacation. This is his 76th trip across the Atlantic. He was presented by the workers of the tunnels, the men who dug the tubes, with a bronze bust of Mr. McAdoo, which will be on exhibition at the Metropolitan Museum of Art shortly.

Mr. Joseph Walker has been promoted from general foreman to master mechanic of the Illinois Central shops at East St. Louis, in place of Mr. W. McIntosh, transferred to Memphis, Tenn. He is succeeded by Mr. James Hoflich, whose previous position as roundhouse foreman has been filled by Mr. Frederick Aunge, who was assistant.

Mr. J. J. Burns, general foreman of the Chicago & Alton, at Chicago, has been appointed general foreman of cars with authority over the entire Alton system, with headquarters at Bloomington, Ill. Mr. Burns succeeds, with extended jurisdiction, Mr. J. H. Milton, who resigned last spring to go with the Chicago, Rock Island & Pacific at Shawnee, Okla.

Mr. H. P. Latta, general foreman of the International & Great Northern shops at Palatine, Tex., has resigned.

Mr. H. W. Burkheimer has been appointed master mechanic of the New Orleans Great Northern in place of Mr. F. Schledorn, acting master mechanic, resigned.

Mr. William Smith, who has been with the motive power department of the Pittsburg & Lake Erie for many years, has been promoted to general foreman of the machine shops at McKees Rocks, Pa. Mr. J. R. Radcliffe, who has had charge of the apprentice work at the shops, has been made foreman of the machine shop, succeeding Mr. Smith. The position of general foreman is a new office.

Mr. Charles J. McNulty has been appointed master mechanic of the Salt Lake & Ogden.

Mr. Edward Posson, Santa Fe, engineer of car construction, will hereafter report direct to the vice-pres-

ident; Mr. M. P. Buck, superintendent of motive power, having charge only of the locomotive department.

Mr. John Tonge, master mechanic and master car builder of the Minneapolis & St. Louis, has tendered his resignation, effective September 1. Mr. Tonge was born at Stalybridge, Lancashire, England, in 1841, and was educated in the common schools. He entered railway service on June 4, 1864, since which time he has held the following positions: To April, 1874, machinist, Central Ohio Ry.; 1874 to December, 1883, machine shop foreman of the Newark shops of the Baltimore & Ohio; January 1 to September 1, 1874, journeyman machinist of the Minneapolis & St. Louis; September, 1884, to November, 1891, machine shop foreman of the same road; from that date till the present time he has held the position of master mechanic and master car builder.

The American Railway Engineering and Maintenance of Way Association has sent out the following notice to its members: "Mr. W. S. Dawley, treasurer of the association since its formation in 1899, has resigned on account of removal to China, and Mr. C. F. Loweth, engineer, and superintendent bridges and buildings, Chicago, Milwaukee & St. Paul Ry., 1359 Railway Exchange building, Chicago, Ill., has been appointed to fill the vacancy, effective August 1, 1909. Acknowledgement is hereby made of the efficient and valuable services rendered the Association by Mr. Dawley as custodian of the funds of the Association during the past ten years, and of his earnest efforts to promote the interests of the organization as a member of the board of direction. Proper action will be taken at the next annual convention of the Association to show its appreciation of Mr. Dawley's services to the organization as a whole."

W. A. Hopkins, electrical engineer of the Wabash at Decatur, Ill., has resigned to engage in other business.

W. B. Embury, master mechanic of the Oklahoma and Pan Handle divisions of the Chicago, Rock Island & Pacific, with headquarters at Chickasha, Okla., has had his jurisdiction extended to include Sayre Station.

Mr. Frank Lane has been appointed the electrical engineer of the Wabash, succeeding Mr. W. A. Hopkins, resigned.

The office of Mr. Joseph O. Osgood, chief engineer of the Central of New Jersey, has been transferred from Jersey City, N. J., to New York.

Mr. E. B. Van Aiken has been appointed the road foreman of equipment, St. Louis division of the Chicago, Rock Island & Pacific, with office at Eldon, Mo.

Mr. P. O'Connor has been appointed an assistant roadmaster of the St. Louis Southwestern of Texas, with office at Commerce, Tex., succeeding Mr. W. F. Sparks, resigned.

The Maintenance of Way Department

Tie Plates

Editor, Railway Engineering:

In order to help the good work along I beg permission to say a few words relative to tie plates, their uses and results. I have on my division the Goldie claw plate with shoulder and Wolhaupter shoulder plate with ribs, which are both good reliable plates. The Goldie plate when once placed will never allow rail to spread, even on the sharpest curves, providing the ties are any good, but it is very difficult to gauge track where Goldie plates are used on both sides. I have gotten some very good results by using Goldie plates on high or outside rail of curves and the Wolhaupter ribbed plate on low side. On straight track where soft ties are used the Goldie and Wolhaupter plates should be used in the same manner, Goldie plate being placed on line side of track and Wolhaupter on gauge side and by using the two kinds of plates together I find that it is much easier and more satisfactory for men to do their gauging of track, by simply moving the Wolhaupter plate, which is placed on gauge side, never disturbing the Goldie plate, as it is very difficult and in fact almost impossible to change or re-gauge with Goldie plates unless plate is taken up entirely and given a new location in order to keep claws from running back to old holes. I have had some experience with various other kinds of tie plates with poor results—smooth bottom plates, flange plate without shoulder and one single-center ribbed-plate, all of which I find are but very little improvement over none at all.

I have on my division a series of four (4) degree curves where I laid new rail in May, 1906, and at time of installing rail put Goldie tie plates on both sides, ties all oak and there has been no spreading of track since, but prior to the time the Goldie plates were put on these curves, they had to be gauged 2 or 3 times a year. As this is a busy time of year and I have lots of work to do, will close my argument and try to say more next time.

Yours truly,

Indiana. Roadmaster.

Ties and Tie Plates

First—Suggestions as to specifications and inspections.

A first class tie should be 8 ft. long, of clear body wood free from bark or spongy heart wood. If a sawed tie it should be 6x9 ins. If hewed, it should be level on 2 sides 6 ins. thick and should not be less than 8 ins. at its small end or more than 12 ins. at the wide end. Second class ties should be any that do not reasonably come up to this standard. They should

be thoroughly inspected both as to dimensions and quality on all sides and no cull ties should ever reach the repair gangs.

Second—Kinds of wood to use on the different lines of this system under various conditions.

For main tracks nothing but first class white oak or yellow pine ties should be used, preferably oak, for the reason that they have the longest life that can be expected from ties, and the less seldom the road-bed of the main line is disturbed for tie renewals the more perfect our track. On branch lines first class cedar ties with tie plates will be found to give good service according to the traffic or quality of the rail that is laid on them.

Third—Statistics as to the cost and life of ties we are now using considered with reference to different kinds of wood under different conditions of ballast, traffic, etc.

White oak ties of first quality have been found to last 8 years under heaviest main line traffic if new and fresh when put in track. Other oak ties that have been a long time in piles before being put in track have been found to require renewing in 5 years. Yellow pine ties of first quality I have found to require renewing in 7 to 8 years, their evidence of decay being that they split open, or in getting wet in the heart they burst open from the inside. This applies to main line and gravel ballast. In yards where drainage is not good or in cinder ballast, oak or yellow pine ties will wear out in 4 or 5 years, their deterioration being principally from the bottom, caused by poor drainage or the chemical action of cinders, in many cases the top of the tie remains quite hard when the bottom is entirely gone. Good cedar ties have been found to last for 10 years under the above conditions, their only failure being the cutting or chafing the rail into the timber under heavy traffic, but which can be overcome by the use of tie plates, the general use of which has not been long enough to determine just what life they will add to cedar ties under these conditions.

Fourth—System of regulating renewels of ties per annum per mile, per rail, etc., main line and side tracks, including best method of making renewals.

Ties should be so handled that not any more ties should be removed from the track in any one year, or from any mile of track, or any length of rail, than will renew all the ties in the number of years found to be the life of the ties. Where previously ties have been put in out of a face, it will require some time to work into a system of general light tie renewals, but this can be accomplished by foreman of repairs using care and selecting only the very worst ties first for renewal. In long passing sidings ties should be handled same as in main tracks. In yards and storage tracks it is better to give the track a light lift every 2 or 3 years and renew all bad ties in so doing. In carrying out the above system in handling ties it will be found that many single ties will have to be put in. The best method to do this is to raise the spikes each side of the tie to be taken out, dig out in front of the tie, but not any deeper than its bed, push the tie forward and by springing up the rail the tie can be pulled out. The depth of the tie then to go in should be carefully noted, the bed of the old made to suit the new tie and the tie pulled in and carefully filled. In this way the solid bed of track which is the most important part of the permanent way will not have been disturbed.

Fifth—Directions to be observed to prevent the destruction of ties in spiking, spacing, etc.

Ties should never be handled by sharp pointed pick or tie hook. Nothing will lessen the life of a tie more than being punctured by this careless way of handling. They should be handled exclusively by hand in putting them in track, placing in perfect position at right angles to the rail and spiked to true gauge, spike driven perpendicular to save all further necessity of having to pull them again.

In spacing ties the head of claw bar will be found to be least injurious to ties in knocking them around, beside being the proper tool with which to do the work, spikes frequently having to be pulled in spacing. The practice of spacing ties with spike mauls or short pieces of rail should not be allowed in any case.

Sixth—Under what conditions is it wise and economical to use tie plates. What design of tie plate is recommended?

Tie plates should be used on all curves 4 degrees or over on main track. They should be used under the main track rails at all switches and they should be used on cedar ties in all track. The Goldie tie plate with the outer rib, in my estimation, is the best from a holding standpoint, if they could be constructed as to have the claws lengthwise of the plate instead of at right angles. Something more is required on all tie plates of the Glendon, Wolhaupter or Servis pattern to hold the rail. This is supplied in the Goldie in the shape of an outside rib which prevents cutting the spike with flange of rail.

Seventh—Cost of putting ties in with different kinds of ballast, method of working, etc.

As in no other item of Maintenance of Way can more extravagance, waste and consequent expense be entailed than in the renewal of ties, foremen in many instances renewing ties that would do another year in order to make a record; it should not be how many ties can be put in by a given number of men in a stated time, but rather how few could be well and judiously put in. In gravel ballast 12 ties per day per man, and in stone ballast 10 ties per day per man, properly placed in track, is a good day's work. The best method of working is to have two men together, each two men taking a rail and putting in what ties are required and finishing up as they go.

New York. Roadmaster.

[This letter and the following were written several years ago upon request of Division Engineer.]

Ties and Tie Plates

Answers to same questions as given in preceding letter:

1.—Specification should state what is wanted precisely and concisely and in plain terms and inspection made rigidly in accordance.

2.—Yellow pine, best quality.

3.—Yellow pine ties first class about nine years on main line; have no statistics relative to other work.

4.—Personal examination by careful Foreman carefully watched by Supervisor and Assistant.

5.—Drive spikes straight and square with the rail. Move with bars or strike on under side with maul for spacing. Use no picks for removing tie. Use tie plugs whenever spikes are drawn.

6. On main line curves. All switch leads of any importance. Base lines and sharp curves in yards and on sidings.

7.—0.135 in gravel ballast, 17 cents in stone ballast; 10 to 12 cents in yards. In general, I think it better to put in ties before Summer work of surfacing, lining, etc., is done, except where track is to be raised, then the work can be facilitated by being done jointly.

Yours truly,

New York. Roadmaster.

Ties and Tie Plates

1.—The best quality of cross-ties should be used for the main line track. Either white oak or yellow pine perfectly sound and straight. In all cases they should be of even thickness and free from sap, the ends to be sawed off square.

2.—Yellow pine or white oak should be used on main line, sharp curves and in yards where there is a heavy traffic. Cedar with tie plates in yards, storage tracks and where there is light traffic.

3.—Cost of tie yellow pine, fifty-eight cents; cedar, forty-seven cents. The average life of yellow pine ties is about seven to eight years and cedar ties about nine years.

4.—In regulating the renewel of ties the Foreman should go over his section carefully and count the poor ties on each mile that are required for the following year, which averages about two ties to every 30-ft. rail or 352 ties per mile.

5.—Spikes should be driven plumb about 2½ inches from edge of tie and when spike is drawn the hole should be immediately plugged. Ties should always be spaced evenly and at right angles to the track.

6.—Tie plates are required to prevent cutting of the tie by the rail and thus prolong the life of the tie. I consider it economical to use the plates on cedar ties in storage yards and where traffic is light. On main line and where yellow pine or oak ties are used would prefer not to use any unless the Goldie plate is used, which I consider the best the tie plate made.

7.—The cost of putting ties in stone ballast is about fifteen cents per tie and in gravel ballast eleven and one-fourth cents per tie. In putting in ties on straight line if rail is not in good surface I would raise it level to save labor. If track is good and needing new ties I would renew without raising by trenching beside old ones that should be removed in order to put in new ones.

Yours truly,

New York. Roadmaster.

Ties and Tie Plates

2.—White oak, yellow pine and cedar ties. Tie plates to be used with cedar ties.

3.—Life of oak and pine ties on gravel ballast from seven to eight years; on sand ballast about six years and cedar ties from ten to fifteen years.

4.—To raise track about one-inch draw out the old ties and put new ties on the old bed. There should not be more than three or four new ties put under one rail each year where this can be done with safety.

5.—When the track is raised one inch ties can be spaced with bar with less damage to them. Spikes should be driven square with the rail. When spikes become twisted they should be drawn, hole plugged and spike driven over.

6.—Tie plates should be used on cedar ties at all places and on sharp curves. I think it would be a good idea to use them on pine ties.

7.—On account of a very wet spring I have put in some ties without surfacing the track, cost from nine to eleven cents each. I would prefer to raise the track and tie it at the same time if everything was favorable.

Yours truly,

New York. Roadmaster.

Ties and Tie Plates

1.—Specifications for Cross Ties.—Ties must be cut from sound live white oak, rock oak or chestnut timber, free from decayed knots, wind shakes and other imperfections, felled between the months of October and April.

First Class Pole Ties.—Pole ties must be six and one-half inches thick not less than seven inches nor more than twelve inches face. Either sawed or hewed faces will be accepted. Ties must be peeled of bark and be eight feet long and square at both ends.

Second Class Pole Ties.—Same as first class with the exception that they should have not less than six inches face.

First Class Sawed Ties.—Ties must be sawed on four sides and be six and one-half inches thick, not less than nine inches nor more than ten inches face and without wane. They must be eight feet long and square at both ends.

Second Class Sawed Ties.—Same as first class with the exception that they be not less than seven inches face and not more than one-half inch wane on each side of face. Ties not squared at ends and varying

more than one inch from proper length will not be accepted. Ties must be delivered on the line of the railway, evenly piled in ranks or tiers like cord wood, leaving at least three feet between each pile, upon ground as high or higher than grade of the road or acceptable to Supervisor and about eight feet from nearest rail, each pile marked plainly with owner's name.

Inspection.—Inspector should have a pole 8 ft. 1 in. long with mark at 7 ft. 11 in. and at 8 ft. He should stand at one end of the tie pile and have men who handle ties roll ties over so he can see four sides and examine both ends.

2. Yellow pine on main line up to curves of 5 degrees, from five degrees up, white and rock oak. Branch track and yards and sidings, chestnut and cedar up to curves of four degrees, yellow pine from four degrees up to eight degrees, from eight degrees up, oak.

3. Life of oak ties on this sub-division of main line is about six years under heavy traffic. Yellow pine, eight years; branch track oak, seven years; yellow pine, nine years; cedar, twelve years; clay and cinder ballast.

4. Three hundred and fifty ties per mile which would be about two ties per rail per year. In putting in ties where roadbed is clay and ashes, track should be raised each year at least one inch in order to let new ties in on old ballast and save breaking up tie bed. Where roadbed is good gravel track should be raised about an inch every other year and arrange so as to raise half the section each year.

5. In spiking ties spiker should be careful to drive spikes as straight as possible and start where there is no check or where spike would come in contact with check. Tie plugs should be used in all places where spikes have been removed. In spacing ties ballast should be removed proper distance ahead of ties and spikes should be loosened and rail sprung so as to allow ties to move easily. A small cedar tie or fence post should be used to drive ties forward. In doing this there should be two spikes driven in each side of tie or post about two feet from each end. By using a man at each side of the tie or post the tie can be spaced very rapidly without destroying ties in track.

6. Would suggest using tie plates on all yellow pine ties, on main track on curves from four degrees up and on oak ties on curves from five degrees up, on all sharp curves, in yards and sidings where traffic is heavy. On cedar ties on all curves from one degree to four degrees and on tangent where traffic is heavy. Tie plates I have been receiving made up as per standard blue print are satisfactory.

7. Cinder and clay ballast ten and one-half cents, gravel ballast eleven and one-third cents; stone ballast eighteen cents. Based above for ashes and clay a raise of one inch by tamping ties at ends and then going back knocking dirt from out of the ends of ties that come out and sliding ties in on old bed and giving necessary tamping. Stone ballast removing old ties and putting in new ties without any raise.

Yours truly,

New York. Roadmaster.

Ties and Tie Plates

The standard specifications are quite satisfactory to the committee with the exception of those referring to the thicknes of the tie. This, it is believed by most should be seven inches to give during the whole life of the tie sufficient timber to prevent the point of the spike from coming through. Many ties my be sound enough to remain in track after 1-in. of cutting if properly adzed, which would have to be removed if the tie were only six sinches thick. There is also considerable wear from the under side of the tie due to tamping and to abrasion by the ballast which should be allowed for. Further with our form of cross-section of roadbed requiring 3-ins. of the tie to be exposed at the ends, it is believed that better line, especially on curves, can be maintained with this extra inch of wood in the ground to resist lateral motion. Uniformity of thickness is especially desirable in ties to be used in gravel ballast in order that where they are to be put in without raising track, the old bed need not be disturbed by having to dig out for a thicker tie than the one removed. Uniformity in width is especially to be sought for in ties for our three tie joints, as it is impossible to tamp the joints properly if large ties are placed at them and their use at the quarters renders it difficult to keep good a surface. The concensus of opinion is strongly in favor of hewn ties, but there is no reliable information in the Committee's hands on which to base a comparison of their life as compared with that of sawed ties. The tie hewed or sawed on four sides is much more uniformly sized than the pole tie. The difference in price between the two may make it desirable to use the pole tie in some cases. In any case the upper and lower surfaces of the tie should be strictly parallel and as free from wind as possible to save labor of adzing to fit the rail later.

It is most important that before placing contracts for ties, on the fulfillment of which the supervisors are dependent for their supply, it should be definitely known from an examination of the contractors' resources, that he will be able to furnish the full number of ties which conform rigidly to the specifications. This is especially important on local contracts in regions where timber supply is on the decrease. Where possible ties should be inspected at the point of shipment to save rehandling. If this cannot be done it is believed that the tie yards should be established at convenient points and provided with ample room and facilities for receiving, inspecting, storing, and reshipping. The inspector should have thorough knowledge of timber,

especially of its diseases, and ability to readily and positively distinguish the different varieties of the same species of timber, especially oaks.

KINDS OF WOOD TO USE ON THE DIFFERENT LINES OF THIS SYSTEM UNDER VARIOUS CONDITIONS.

For the main line and important branch lines under heavy traffic the best of white oak or yellow pine should be used. On lines of light traffic where the element of rot would be a greater factor in the deterioration of the tie than the wear and cutting due to hard usage, good cedar ties may be used if plated. On branches where oak of good quality or chestnut can be obtained at a reasonable price they may be used. The yellow pine should be of the long leaf variety and off a stump that has not been tapped for pitch. The principal defect of these ties is brittleness, splitting and decay from the bottom upward. They require more care in spiking to prevent breaking out at the side than do other kinds. Such difference in definition exist in different localities as to what "rock oak" is, that the retention of the word in the specifications is believed to be source of danger except where the inspectors are exceedingly well trained. The offering of ten cents more for local oak ties than for chestnut is a great temptation to the contractors to put in oak ties of many inferior grades under the heading of "rock oak," many such lasting only three or four years as against six or seven years life of the chestnuts, for which ten cents less is paid. Wherever ties of different woods are used on the same territory they should be kept separate, each on its particular part of the section. Of course if both white oak and yellow pine are furnished the oak should be laid on the curves. Cedar ties even if well plated are hardly suitable for heavy curvature except under very light traffic. The yellow pine tie appears to be the least affected by frost of any.

STATISTICS AS TO THE COST AND LIFE OF TIES WE ARE NOW USING, CONSIDERED WITH REFERENCE TO DIFFERENT KIND OF WOOD UNDER DIFFERENT CONDITIONS OF BALLAST, TRAFFIC, ETC.

Below are given the average cost and life of first class ties of various woods in different kinds of ballast as based on the reports of the various members of the committee.

Kind	Average Cost	Average Life				
		Stone	Gravel	Cinders	Clay	Sand
White Oak	$ .59	9	7½	7	6	6
Yellow Pine	.57	9	7½	6½	8	5
Cedar	.49	..	10½	10	..	9
Chestnut	.45	..	6	6	..	..

Yellow pine ties have a longer life in stone ballast than in gravel it is thought, and oak a still longer one proportionately, on account of its great hardness. While the life of all ties is materially shortened by the action of water on cinder ballast in wet cuts or in poorly drained yards, there are no figures to show that their usefulness is decreased in cinder ballast if the same is kept thoroughly drained.

Good white oak ties generally fail about equally from rot and from cutting, yellow pine from splitting or from bursting on account of internal decay. (In wet places from decay from the under side). Their spike holding qualities are believed to be inferior to those of oak. Cedars as a rule fail from cutting, enlargement of spike holes or, if the timber be old growth, from piping or heart rot. Chestnuts are particularly susceptible to sun checking. The "rock" or other inferior grades of oak decay internally and are often deceptive on account of the outer shell remaining hard while the inside is almost entirely rotted away.

The question of obtaining the maximum life from every tie is daily becoming more important for it is well known that the available supply of timber is decreasing. If the tie can be made in any way to last while the timber for a new tie is growing, the present forests will supply the present demand; but at the present rate of consumption a large increase in the planting of new forests is imperative if wooden ties are to continue in use. Any method that will prolong the life of a tie to the time required to raise another to replace it will give it a life approximately equal to that of the rail and would have an important bearing on the method of renewal which is taken up under the next heading (The methods of tie preservations are the subject of special report.)

SYSTEM OF REGULATING RENEWALS OF TIES PER ANNUM, PER MILE, PER RAIL, ETC. MAIN LINE AND SIDE TRACK INCLUDING METHODS OF MAKING RENEWALS.

The proper basis for estimating tie renewal is previous necessary tie removal. All ties and switch timber when put in should be dated as per the standard recently adopted. The date mark, kind of work, location and cause of removal of all ties taken from track should be noted on the Foreman's material reports. Such records extending over a period of years equal to the extreme life of the ties give absolute knowledge to be used in estimating on renewals. In the absence of such information the average life is guessed at with considerable accuracy and the total number of ties on the territory divided by this figure to get the quantity required for renewal for the year. Any empirical unit per mile or per rail length is unsatisfactory as it fails to take proper account of the kind of wood, age and weight of rail, percentage of grade and curvature, quality of ballast, amount of traffic, drainage, climatic conditions and standard of maintenance required. Untill the present system of dating has begun to produce results it would seem to have each foreman go over his section carefully, marking all ties that he thinks should be removed, these markings to be examined later by the supervisor or assistant. The average

figures commonly used in estimating renewals are 350 to 380 for main tracks, 250 to 300 for side tracks. This gives for main track from 2 1-3 to 3 new ties per 30 ft. rail. In important yards ties will often wear out faster than in main tracks and no general rules for renewal can be made to cover all the local conditions.

METHODS OF RENEWAL.

In any consideration of a tie renewal it should be borne in mind that (1) the less frequently the track is disturbed, and (2) the more uniform the bed on which the tie rests, the better will be the track.

While it is doubtful if the English method of whole sale renewal of ties, rail and ballast "out of face" (even when preservative methods have greatly prolonged the tie life) can ever keep all the track in as good riding condition as first-class American standards demand; it has the advantages of concentration of labor and infrequent disturbance of track which would make a judicious compromise between it and the practice of indiscriminately tieing up every rail length each year, appear well worth considering. It is believed that by general care a system may be gradually introduced whereby one-fourth of every section is retied each year and practically no ties are put in on the remainder. Ties ought to, and most of them do, last eight years in main track under average conditions. The ties that are put in on the first quarter of the section ought to be good for that length of time but by this method of working an opportunity is given in four years or at the time when the ties should be only half worn, to go over that portion and replace any where the wear is especially hard. It may be advisable on the main line to re-tie every third year doing up to a third of the section at a time, more especially where the sections are so short that the element of working at long range does not enter to such an extent.

The important reason for the adoption of some such method as outlined above is that it enables us to fulfill the second requirement of proper tie renewal namely, preservation of uniformity in the tie bed, by making and enforcing, for all cinder and gravel ballasted roads, the rule that ties shall not be dug in. No track raised on gravel or cinder will keep up to exact gauge for a year and it is safe to say that it will go down from 1-in. to 1½-in. in gravel and from 1½ in. to 2½ in. in cinders in four years. Therefore on the quarter or other fraction of the section that is to have new ties in any given year, the track should all be raised from 1 in. to 2½ in. according to ballast, the ties that are to remain should be tamped (and enough of those that are to be removed to ensure steady riding during the work) the decayed ties taken out, new ones put in, and every tie tamped both old and new to a uniform bearing, every tie thus being given a new bed at practically a uniform lift above an uniformly compacted old tie bed. It is urged that this method of raising before tie renewal is the only practical way to obtain an undisturbed tie bed under the whole of the track. Of course if it is really necessary to put in a tie here and there at places where there is no lift to be made, it may be done by drawing the spikes from the adjacent ties sufficiently to allow the rail to be raised enough to permit the old tie to be drawn out and the new one inserted. The above does not apply to stone ballasted track with the force that it would if the stone furnished were of smaller size as it should admit of its being properly tamped to a uniform bearing surface under the whole of the tie.

DIRECTIONS TO BE OBSERVED TO PREVENT DESTRUCTIONS OF TIES IN SPIKING, SPACING, ETC.

Ties should be handled by hand as much, and by tools as little as possible. The use of a pick or a tie hook even in pulling should be strictly prohibited. In spiking the first requisite is to have the tie held up firmly to the base of the rail and the second, a man that will bend his back enough to allow the hammer handle to assume a horizontal position at the end of the stroke. A great fault in spiking is to start the spike inclined and to draw it by subsequent blows to an upright position. This leaves in the tie a hole larger than the spike itself serving to admit water to the interior of the wood. All spike holes should be plugged as soon as the spike is drawn, the plug head being adzed off if necessary, and the spike driven in the plug if possible.

In spacing ties, if the track is raised as it generally should be after rail renewal, the tie can be readily removed with a bar. If they have to be moved while tight they may be bucked with a fence post or small tie provided with handles and swung between two men as a ram. A broad faced wooden mallet may also be used without harm but the proper tool for moving ties is the bar.

The matter of adzing the tie to a true plane to fit the rail bases is very important as is the quick detection of any tendency of the rail to cant and a prompt correction of this fault by adzing. Ties are often injured in stone ballast by the tamping pick as a result of the ballast not being properly dug out before tamping, or by tamping under the extreme end and in a direction parallel to the length of the tie. It is also very easy to make a bad tie out of a good one by trying with a bar or pick to see if it is good.

UNDER WHAT CONDITIONS IS IT WISE AND ECONOMICAL TO USE TIE PLATES? WHAT DESIGN OF PLATE IS RECOMMENDED.

Where the price of two tie plates and the cost of applying them is less than the additional value they give the tie, they are of course economical. They may be economical where this condition is not fulfilled but where greater safety and stability, and decreased cost of labor in regaging and less frequent

expenditure of labor in tie renewal can also be counted in as well as the actual reduction in the "annual cost" of the tie. With cedar tie plates are a necessity, on tangents with good white oak or yellow pine ties it may be doubted if they are not a luxury. They should be used on all curves on the main line and on all heavy curves, say over three degrees on branch lines of light traffic, also on all switch ties that have at all severe service and in all important curved yard tracks. Tie plates should be used under all frogs except where the traffic is exceptionally light.

There is great diversity of opinion as to the design of plate to be used, some preferring the standard "Glendon" or "Wohlhaupter" while others want the "Goldie" or none at all. It would seem that the attractive feature of the "Goldie" plate is the shoulder that fits against the base of the rail and acts as a brace. While some prefer the claw leg of the "Goldie" many prefer the longitudinal rib of other designs. It is thought that a combination of the shoulder such as the "Goldie" has, with some means of securing the plates to the tie without damage to the wood fibre and which will combine the closeness of adhesion of the parallel rib and the resistance to lateral displacement that the "Goldie" claw shows, would be most acceptable to all.

COST OF PUTTING IN TIES WITH DIFFERENT KINDS OF BALLAST, METHODS OF WORKING, ETC.

The cost of putting in ties in the various kinds of ballast, as based on average of all reports, is given as follows:

	Ballast.			
	Stone.	Gravel.	Cinders.	Dirt.
Highest cost	18	13½	11½	11½
Lowest cost	13½	10	7½	8
Average cost	16	11¼	10	10

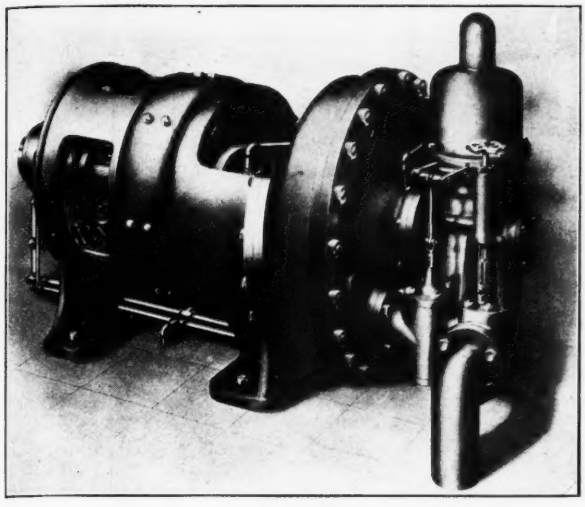
When the average allowance for each section has been made and the ties begin to arrive they should be distributed by work train or shipped to the desired points by freight, unloaded and placed in standard piles, careful note being taken to detect any that have been improperly passed by the inspector. If the ties are to remain piled through considerable dry weather they may be covered with a layer of sod to prevent their taking fire. When the ties that are to be removed are marked and the track raised, the new ties may be peddled out to place. All the spikes should be drawn from the old ties that are to come out and the same withdrawn with picks, the new ties placed by hand or by prying on end with a bar, care being taken if pole ties are used to put the large ends on the outside of curves and to alternate them as near as possible on tangents. The new tie should be put in heart side down and marked for the base of rail on the line side. It should then be carefully held up to both rails at once to see if there is any wind in the top surface and adzed if necessary to a true plane. The ties should be shovel tamped before spiking if the amount of lift requires it, then lined to base of rail, squared to the rail, held up firmly, preferably with a bar on each side of the tie, and the spikes driven vertically and snug to the rail, not too close to the edge of the tie. Care should be taken to note again before spiking to gauge to have the tie square to the rail. In all, tamping the points to be watched are, to get the ballast under the rail, to have the men on the opposite sides of the tie tamp directly opposite each other and in uniform time, to tamp horizontally and to dig out the ballast properly before beginning to tamp. After the newly tied track is surfaced, gauged and lined, the old ties should be examined and the date marked, kind of wood, location and cause of removal noted before the same are picked up for burning or for sale.

Train Lighting Turbo-Generator Set

The new Westinghouse "train-lighting" turbine-generator set meets the exacting requirements of a small steam-driven generating outfit for train-lighting, excitation, or other small-power, direct-current service, securing to a marked degree the advantage of compactness and minimum weight which result from the improvements in design of both its electrical and steam elements. The generator output is 25 kilowatts at 125 volts, and is designed to run at 3,600 revolutions per minute. The turbine element is of the impulse class but of novel construction. A single wheel is employed, involving a re-entrant path for the steam which is expanded practically to exhaust pressure in the nozzles.

The generator is compound-wound, insuring close voltage, regulation, while its 4-pole field structure with auxiliary commutating poles, makes possible diminished weight, and length of commutator, and thus, shortened overall dimensions, accomplished in no other design. The compact structural connection between the turbine case and generator frame also contributes to shortening the overall shaft length, adapting the outfit admirably for installing in the restricted space of the baggage car, where, in train-lighting service it is intended to be placed. On account of the possible oscillation and vibration of the car, oil rings are not relied upon for lubrication of the two bearings, an oil pump, attached to the turbine, being provided to insure circulation of oil in ample quantity while the outfit is in operation. Provision is also made for accurately balancing the rotating part, avoiding any possible vibration that might occur from this cause.

A well-designed fly-ball governor and geared directly to the turbine, controls a nickle-bronze balanced puppet valve. The governor mechanism is unique in design, insuring excellent regulation, stability, and certainty of operation. With the turbine is furnished a combined automatic and hand throttle valve, the automatic feature of which is operated by a weight held by a spring against centrifugal force, and



Train Lighting Turbo-Generator Set.

entirely independent of the main governor. The apparatus is exceedingly simple and hence certain in its operation. The device may be regulated to come in at any predetermined speed.

The new Westinghouse train-lighting turbo-generator set, embodying superior advantage of lightness, empactness and efficiency, as above noted, was exhibited, for the first time, in the Westinghouse space at the conventions of the Master Mechanics' and Master Car Builders' associations at Atlantic City.

New Pennsylvania Station, New York

The Pennsylvania Railroad placed in position the last piece of stone in the exterior of its new station in New York City. This involved the completion of stonework enclosing some eight acres of ground, and marks a most important step in the further progress of this undertaking.

To enclose this vast area has necessitated the building of exterior walls aggregating 2,458 feet—nearly half a mile—in length, and has required 490,000 cubic feet of pink granite. In addition, there have been utilized inside the concourse 60,000 cubic feet of stone. A total of 550,000 cubic feet of granite have thus been utilized in the construction and ornamentation of this building. It took 1,140 freight cars to transport these 47,000 tons of stone from Milford, Mass.

In addition to the granite, the construction of this building has called for the use of 27,000 tons of steel. There have also been set in place some 15,000,000 bricks, weighing a total of 48,000 tons. The first stone of the masonry work on the building was laid June 15, 1908. The entire masonry was thus completed in approximately thirteen months after the work was begun.

Built after the Roman Doric style of architecture, the building covers the entire area bounded by Seventh and Eighth Avenues and 31st and 33rd Streets. The depth of the property on both streets is 799 feet 11¼ inches, and the length of the building is 788 feet 9 inches, thus allowing for extra-wide sidewalks on both avenues. The walls extend for 430 feet 6 inches from 31st to 32d Streets, the Seventh Avenue facade signalizing the main entrance.

In designing the exterior of the building, Messrs. McKim, Mead, White, the architects, were at pains to embody two ideas: To express in so far as was practicable, with the unusual condition of tracks far below the street surface and in spite of the absence of the conventional train shed, the exterior design of a great railway station in a generally accepted form; and also to give the building the character of a monumental gateway and entrance to a great metropolis.

Apart from these two ideas, the plan of the station was designed to give the greatest number of lines of

The Pennsylvania Station at New York, 8th Ave. Facade and 31st Street Side.

The Pennsylvania Station at New York, 7th Ave. Facade and 33rd Street Side.

circulation. The structure is really a monumental bridge over the tracks, with entrances to the streets on its main axes and on all four sides. In this respect this building is unique among the railway stations of the world, affording the maximum amount of entrance and exit facilities possible.

The Seventh Avenue facade is composed principally of a Roman Doric colonnade, double at the carriage entrances at the street ends and at the main front entrance for pedestrians in the center, each of the columns being 4 feet 6 inches in diameter and 35 feet high. Above the central colonnade is an entablature surmounted by a clock with a dial 7 feet in diameter. The center of this clock is on the axial line of 32nd Street, and 61 feet above the sidewalk.

This Seventh Avenue facade was conceived especially to express in largest possible fashion a monumental gateway. It may be compared in a greatly magnified manner to the Brandenburg Gate in Berlin, through which passes so much of the traffic of that city.

The main body of the building approximates in height the Bourse of Paris, reaching 76 feet above the street level. With entrances through each of the two corners of the station on Seventh Avenue there are carriage drives each about 63 feet wide, or the width of a standard New York City Street, fronted by double columns and pediments. The frontage on 31st and 33rd Streets are similar. The walls of the exterior of the carriage drives are of pilaster treatment for a distance of some 279 feet.

Midway along the sides of the building, signalizing the entrances on 31st and 33rd Streets, are series of columns of the same dimensions as those on the Seventh and Eighth Avenue facade, for a distance of 117 feet. Above these colonnades there are also sculptured groups supporting large ornamental clocks. For 116 feet beyond there are interruped colonnades, after which the walls are of pilaster treatment to Eighth Avenue, with the exception of 45-ft. colonnades marking entrances to the concourse.

The Eighth Avenue frontage is treated on the plan of pilasters except for 44 feet 6 inches which are broken by columns into intervals of three spaces to mark another spacious entrance to the main floor of the concourse.

One of the distinctive features of this building is the waiting-room, which extends from 31st to 33rd Streets, it walls parallel to Seventh and Eighth Avenues, for a distance of 314 feet 4 inches. The height of this room is 150 feet and its width 108 feet 8 inches. The walls of the waiting-room above the main body of the building contain on each side three semi-circular windows of a radius of 33 feet 4 inches and 66 feet 8 inches wide at the base. There is also a window of like size at each end of the waiting-room.

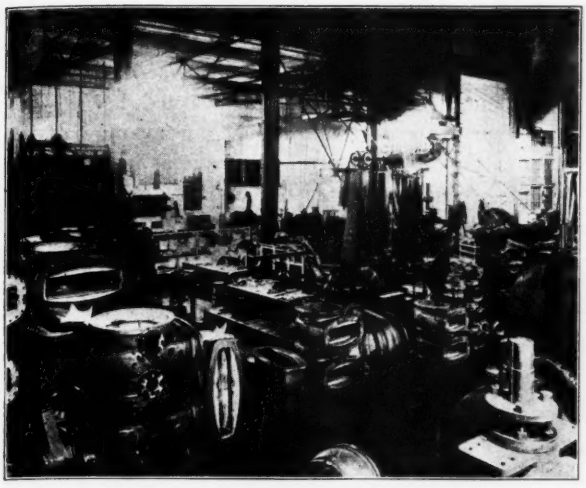
The dignified design of the interior of the general waiting-room, while fully adapted to modern ideas, was suggested by the great halls and basilicas of Rome, such as the baths of Caracalla, Titus and Diocletian, and the basilica of Constantine, which are perhaps the greatest examples in history of large roofed-in areas treated in a monumental manner.

While the facades of the station were intended to suggest the imposing character of these ancient Roman temples and baths, the impression intended to be made upon the layman approaching the station, in full view of the exterior of the general waiting-room with its huge semi-circular windows, is that of one of the leading railway stations of the world.

The Lighting of Erecting Shops and Heavy Machine Shops

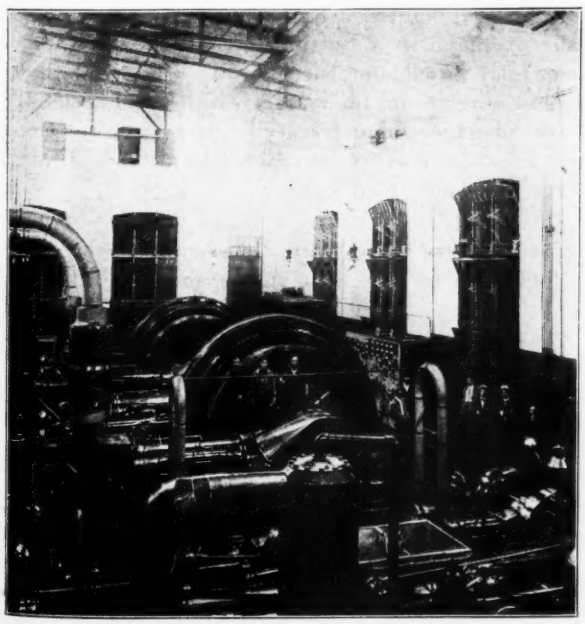
By S. P. Knapp

The artificial lighting of the work in erecting shops and heavy machine shops that the employees can have working conditions equal to daylight, has, in the past, been a difficult problem. The great



Cooper-Hewitt Illumination of Machine Shop.

height of the heavy cranes has made it necessary to place most, if not all, of the lighting units underneath the cranes. In many instances it has been impossible to install lamps anywhere except on the side walls, although it is readily apparent that with an arc or incandescent cluster in that position much of the light is absorbed by the dark walls, and consequently in the center of the room the lighting is most unsatisfactory. Again with low lighting from the side walls, locomotives or high machines may hide the source of light, producing large shadows in the center of the floor. Were it possible to obtain from skylights all the daylight required for satisfactory lighting, this arrangement would unquestionably give the best distribution and diffusion. Accordingly, if these satisfactory conditions can be artificially duplicated by placing the light source directly over the machines and workmen, a better distribution and the avoidance of eclipsing shadows will be obtained.



Cooper-Hewitt Illumination of Engine Room.

The Cooper Hewitt Lamp, with its perfect diffusion resulting from a large luminous surface, makes possible the satisfactory illumination of a floor surface from a much greater height than was formerly considered possible. At the same time the comparative length of light source in the 50-inch tubes makes

Cooper-Hewitt Illumination of Erecting Shop.

it possible for heavy cranes to pass underneath without causing any sharply defined shadows. This, with the absence of glare, as obtained from other illuminants, makes it possible for the mechanic to distinguish details in his work with accuracy.

The accompanying photograph shows an erecting shop of one of the large railroad systems lighted by 34 type F Cooper Hewitt lamps, giving 28,900 candlepower at a current consumption of 13.6 kilowatts. The dimensions of this building are 442 by 94 feet, or 41,550 square feet. The height of the lamps from the floor is 50 feet, and 1,225 square feet of floor surface is allowed per lamp. In an adjoining erecting shop of three-fourths the size, two and one-half times as much power is being used to furnish arc lighting from the side walls, with most unsatisfactory results.

In heavy machine work, some idea of Cooper Hewitt illumination can be obtained from the accompanying view of a section in a room of the Rensselaer Manufacturing Company, at Troy, N. Y., where hydraulic valves to the weight of twenty-six tons are manufactured. This room contains 10,180 square feet of floor surface and is lighted by ten Type K Cooper Hewitt lamps, giving 7,000 candlepower. This installation has been in use since October, 1907, and the total cost for maintenance has been $24.00 to June 1, 1909. It is interesting to compare this maintenance item for almost two years (in which the labor element is almost wholly eliminated), with that of any of the other systems of lighting, and to contrast it with the attention demanded by arc-lighting systems, particularly of the flaming type, which if used many hours per day total a maintenance cost almost prohibitive.

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and Maintenance of Way

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The Future Timber Supply

In circular No. 166 on The Timber Supply of the United States, Mr. R. S. Kellogg, assistant forester, writes of our future timber supply. We have been told again and again of our decreasing supply and have been given the reasons for it, but this official statement brings it to our attention very forcibly.

"Taken as a whole, the annual growth of our forests under these conditions does not exceed 12 cubic feet per acre, a total of less than 7 billion cubic feet. That is, we are cutting our forests three times as fast as they are growing. There is menace in the continuance of such conditions. While we might never reach absolute timber exhaustion, the unrestricted exploitation of our forests in the past has already had serious effects, and it will have much worse if it is allowed to continue unchecked. White pine, for instance, which was once considered inexhaustible, has fallen off 70 per cent in cut since 1890, and more than 45 per cent since 1900. The cut of oak, our most valuable hardwood lumber, has decreased 16 per cent since 1900, and that of yellow poplar 22 per cent. The same story will be told of other woods if they are not conserved.

"The fact that timber has been cheap and abundant has made us careless of its production and reckless in its use. We take 250 cubic feet of wood per capita annually from our forests, while Germany uses only 37 cubic feet, and France but 25. On the other hand, Germany, who has learned her lesson, makes her state forests produce an average of 48 cubic feet of wood per acre. We have as fast-growing species as Germany, or faster, and as good or better forest soil if we protect it.

"The necessity for more farm land may eventually reduce our total forest area to 100 million acres less than it is at present. It is entirely possible, however, to produce on 450 million acres as much wood as a population much greater than we have now will really need if all the forest land is brought to its highest producing capacity and if the product is economically and completely utilized. But to reach the necessary condition of equilibrium between timber production and consumption will take many years of vigorous effort by individual forest owners, by the States, and by the National Government. None of them can solve the problem alone; all must work together."

The Use of Alternating Currents in Railway Signaling

By W. K. Howe

(Continued from July issue)

Having now spoken of the causes which led to the use of alternating currents in railway signaling, of the uses to which it has been put and of its advantages, disadvantages, etc. I desire now to discuss briefly the Alternating Current track circuit as applied to electric traction roads.

I have had prepared and distributed to you a series of circuit plans, Figs. 1 to 12 inclusive, which I desire to use as a basis for discussion. I have shown the power line in relation to the other apparatus in Fig. 1 only, having omitted it from the other figures for the sake of simplicity. Furthermore I have shown the same relay throughout, except in Fig. 8, although there are other relays on the market which could be used.

Alternating current track circuits for use on electric lines are divided into two general classes, viz., "One Rail" and "Two Rail."

One Rail Track Circuits are those in which but one rail is retained for the propulsion current, the other being given up for signaling as shown by Figs. 1 and 2.

Two Rail Track Circuits are those in which both rails are retained for the propulsion current, and are also used for signaling as shown by Figures 3 to 8 inclusive.

One Rail Track Circuits are permissible where one rail per track is sufficient for the propulsion current and where broken rail protection is not required. On account of their comparative simplicity they are desirable for use in yards or other complicated situations where the use of the reactance bonds required in connection with two rail track circuits may be undesirable.

One of the chief electrical differences between one and two rail track circuits is that in the former a difference of potential is created between the rails by the popuLsion current in direct proportion to the length of the track circuit, the resistance of the rail and the amount of propulsion current flowing in the continuous rail.

This limits the commercial length of one rail track circuits whereas in two rail track circuits no inter rail potential exists due to the propulsion current on account of the fact that each rail carries approximately 50% of the current.

Two types of one rail track circuits are illustrated. They differ in the means employed to limit the amount or effect of such direct current as may be shunted through the Relay and Transformer when traction current flows in the continuous rail, thereby producing inter rail potential.

Referring to Fig. 1, for example, if propulsion current flows down rail B, as shown by the heavy arrow, a certain portion of it will be shunted through the Transformer, Rail A and the Relay as shown by the light arrows, due to the resistance of rail B. The amount of such shunted current depends on the length of track circuits, the size of the rail, the amount of propulsion current per rail and the resistance of the path through relay and transformer from point 1 to point 2, see Fig. 1. The greatest amount will flow through the relay if the rear wheels of a car are standing so as to short circuit the transformer while propulsion current is flowing in rail B. Likewise the greatest amount will flow through the transformer if the wheels of a car are standing so as to short circuit the relay while propulsion current is flowing in rail B.

In the circuit (Fig. 1) the amount of this shunted current is limited solely by the resistance R and R1, whereas in the circuit (Fig. 2) it is limited at the relay end, partly by the resistance R and partly by the reactance coil X, which is in shunt with the relay and has a high resistance to alternating current and a very low resistance to direct currents. The shunted current at the transformer end is limited solely by the resistance R1, but the effect of such current on the transformer is limited by the design of the transformer, i. e., the transformer may have an air gap in the magnetic circuit which prevents the shunted direct current from magnetizing it too highly and thus causing heavy currents to flow in the primary with a resultant drop in voltage at the track.

Referring again to Fig. 1. If resistance R and R1 should be made too great, the track circuit would require too high a voltage (A. C.) between rails and would make the circuit supersensitive to leakage variations between rails. Therefore this type of track circuit is limited to cases where the drop in the propulsion rail (B) does not exceed 15 volts between points 1 and 2. This corresponds to a current of approximately 1500 amperes flowing in 1000 ft. of 80 lb. rail of ordinary resistance.

The circuit, Fig. 2, can stand a very much greater drop in the propulsion rail without a corresponding increase in the resistance of R and R1, due to the construction of the transformer and the use of reactance coil X which permits the flow of a much greater shunted current without affecting either the relay or the transformer. This being the case, the circuit, Fig. 2, is usable on longer track circuits and with heavier propulsion currents than the Fig. 1 circuit.

The circuit, Fig. 1, has the advantage that it consumes a smaller amount of energy and, due to the high resistances (R and R1) employed and the small amount of current permitted to flow in, the relay and transformer, these devices may be placed a relatively long distance from the track circuit without excessive wire cost. In fact all relays at an ordinary interlocking plant can be placed in the tower, a single transformer in the tower being used to feed all track circuits with energy. This is of especial advantage where it becomes necessary to repeat all track circuits into the tower as it does not cost as much as to repeat by means of secondary relays and is much safer. In this connection may be mentioned another advantage of the circuit, Fig. 1, viz., the resistance units R and R1 are relatively small, as indicated by the fact that all of the fuses and resistances for an entire interlocking plant may be placed on a single slate panel in the tower.

This scheme of using one large transformer in the tower and of centralizing all track relays is in use at several interlocking towers with excellent results.

In concluding, the discussion of single rail track circuits the following should be remembered with reference thereto, viz.:

(a)—Single rail track circuits are permissible where one rail per track is sufficient for the propulsion current and where broken rail protection is not required. As to whether one rail per track is sufficient should be decided upon jointly by the signal and power departments of the railroad in consultation with the Signal Co. On the one hand, if there is not enough return conductivity in the rails, the lights in the train will vary excessively in brilliancy when the train is started and stopped. Furthermore, the trains will run slower than otherwise and the full consumption will be excessive. On the other hand, if both rails are retained it will cost much more for signal appliances and signal power and the complications will be greater, especially through interlockings.

In general it may be stated that single rail track circuits find their greatest usefulness in terminal work and for slow speed routes, through interlocking plants on account of their low cost, small power consumption, comparative simplicity and adaptability to foulding protection and complicated track circuit layouts through switches, etc.

(b)—Track circuits of the type shown by Fig. 1 are usable wherever the drop in the traction rail between the points 1 and 2 does not exceed approximately 15

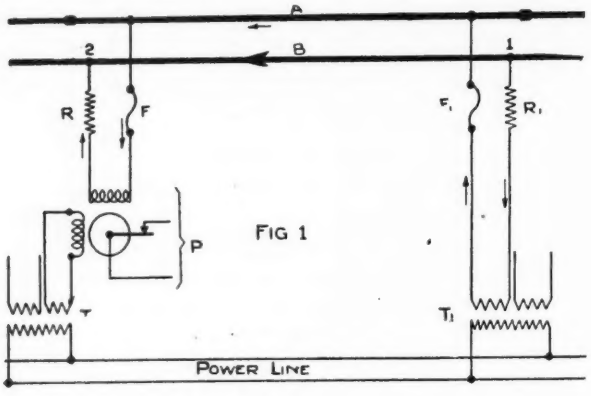


FIG 1

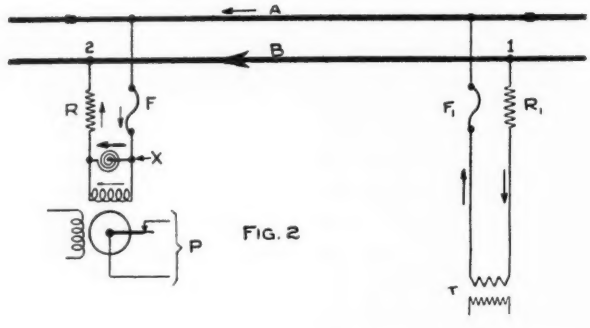


FIG. 2

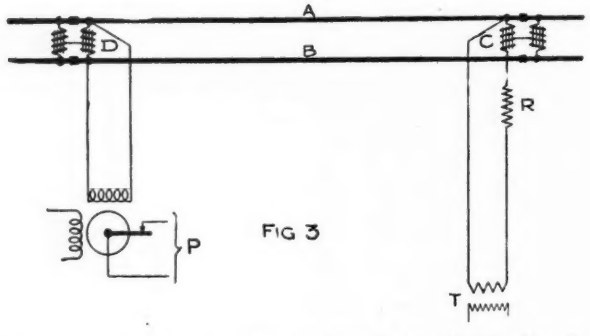


FIG 3

volts. As a matter of fact, it will be found that in the great majority of cases where it is safe to use single rail track circuits at all the Fig. 1 type can be employed.

(c)—Single rail track circuits of the type shown in Fig. 2 should be used where permissible and where the voltage drop in the traction rail exceeds 15 volts.

(d)—The continuous rails of each track may be cross bonded as often as desired.

Coming now to a consideration of two rail track circuits, your attention is directed to Figs. 3 to 8, inclusive:

Two rail track circuits are used wherever it is necessary to retain both rails for the return of the propulsion current to the power house, as explained in concluding paragraph (a) of the discussion of single rail circuits.

The two rail track circuits in commercial use are of two general types, viz., those employing balanced reactance bonds with iron cores, see Figs. 3, 5 and 8 and those employing reactance bonds without iron cores, see Fig. 4. For brevity they will be spoken of as Iron and Ironless bonds, respectively.

Two Rail Track Circuits are again divided into "Centre Fed" (see Figs. 5 and 8), and "End Fed" (see Figs. 3 and 4). Thus a two rail track circuit may be of the Iron bond center of End Fed type or the Ironless bond centre of End Fed type.

The function of a reactance bond is to keep the rails electrically continuous for the propulsion currents and at the same time electrically separated, so to speak, for the signaling current.

They are "bonds" because they contain copper conductors by which the ends of the rails are joined together and "reactance" bonds because they offer a comparatively high resistance to the passage of alternating currents sent through them from rail to rail.

The Iron core bonds usually consist of eight turns of copper conductor of very large carrying capacity placed around but insulated from an iron core, the whole being placed in an iron box and the coils being connected to the rails as shown at C and D, Fig. 3, for example. Centre taps are provided on each end by means of which the various track circuits are connected together so as to form a continuous path of low resistance for the propulsion currents all as shown in the various figures.

It is to be noted that the propulsion current flowing down the two rails passes through the two halves of each bond in opposite directions with the result that it has no magnetic effect on the bond unless more current flows in one rail than the other, in which case it would have a magnetizing tendency, which, if too great, would lower the reactance of the bond, changing its resistance to alternating currents and lowering the relay voltage. As this difference of current in the rails, called unbalancing, is likely to occur, the bonds are designed with an air gap in the magnetic circuit which makes them much less sensitive to unbalancing. It is good practice to design the bonds to take care of an unbalancing of 20% without causing a harmful variation in the reactance. By 20% is meant that the difference of the currents in the rails shall not exceed 20% of their sum.

As regards sizes, etc., bonds such as are used on the New York Central are wound with 1,250,000 circular mill copper bars, having a resistance of about .00014 ohms per pair to the traction current, a continuous current capacity of about 4,000 amperes per track, an unbalancing capacity of 1,000 amperes and weight about 1,500 lbs. per pair in their iron case when filled with oil.

Those used in the Hudson Tunnels are wound with 750,000 circular mill copper, having a resistance of about .00073 ohms per pair to the traction current, have a continuous current capacity of about 1,300 amperes per track, an unbalancing capacity of 500 amperes and weigh about 950 lbs. per pair in their iron cases when filled with oil.

Having now spoken of the relation of the reactance bond to the propulsion current, let us consider them with reference to the alternating signal current.

If an alternating current is caused to flow through a reactance bond from rail to rail it will encounter a resistance many times higher than that of the copper. For example the ohmic resistance of the New York Central bonds from rail to rail is about .00028 ohms, not including the leads to the rails, whereas the impedance or resistance to 25 cycle alternating current is .055 to .06 ohms each, or about 200 times higher than the ohmic resistance.

The reason for this is as follows: Whenever a current is caused to flow through a coil, especially when wound around an iron core, a strong magnetic field is produced which in becoming established produces a counter electro-motive force in the coil which opposes the impressed voltage and delays the building up of the current. If now, this current is caused to alternate many times a second, it will never have a chance to build up to its full value, i. e., as represented by a constant voltage divided by the ohmic resistance, hence the apparent resistance of such circuit, i. e., the A. C. voltage divided by the A. C. current, will be many times higher than a direct current voltage divided by the resulting current. The more the iron or the more the turns, or both, the more will be this apparent resistance or impedance. Furthermore, the impedance increases with the frequency. For example, if a bond has an impedance of .06 ohms at 25 cycles, it will have an impedance of about .14 ohms at 60 cycles.

Returning now to the bond, if a transformer is connected through a resistance to the rails as shown by Fig. 3, it will send a certain amount of current through bond C and therefore, on account of the impedance of the bond, a difference of potential will be created between the rails and a certain portion of the transformer current will be caused to flow down the rails and through the reactance bond D at the other end of the track circuit.

It is this current through bond D that produces the necessary voltage drop to operate the relay. As stated before, the impedance of an iron core bond is about .055 ohms at 25 cycles, therefore to produce sufficient voltage to operate a relay of the type shown, a current of about 6 amperes is required to flow through bond D which in so doing produces about .35 of a volt drop.

In order to send this current down the rails and through bond D, about 1.5 volts is required across the rails at the transformer for a 1,600 ft. track circuit. Now this voltage will send about 30 amperes through bond C, which with the current down the rails, makes about 35 amperes to be delivered by the transformer for a track circuit of above length.

One not familiar with the peculiarities of alternating current might think a mistake had been made in saying that 35 amperes is the total current since 30 amperes flows in the bond C and 6 amperes down the rails. But this is not a mistake, since alternating currents cannot be added up directly in this way unless the characteristics of the various multiple circuits are identical. For example if there is more reactance in one branch circuit than in another the current in the first circuit will lag behind that in the second circuit with the result that when one current is high the other is low and vice versa and therefore ammeters are placed in the different branch circuits and their readings added the sum will not be the same as the reading on one ammeter placed in the common portion of the circuit.

A low resistance, R, is used to prevent short circuiting the transformer when a train is passing. Therefore to send above current of 35 amperes through this resistance and through the track circuit requires about 3.5 volts at the transformer.

Therefore, the total energy required per track circuit is 3.5 volts times 35 amperes, or 123 volt amperes.

Now, it is a characteristic of alternating current that when flowing through a circuit containing reactance, the true energy is not represented by the volts times the current as in the case of direct current, but is always less. The amount that it is less is called the power factor. For example, we speak of

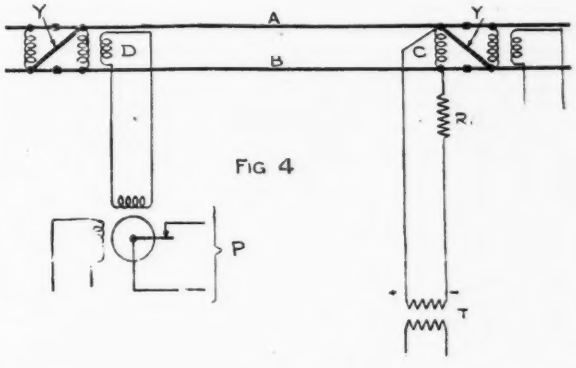


FIG 4

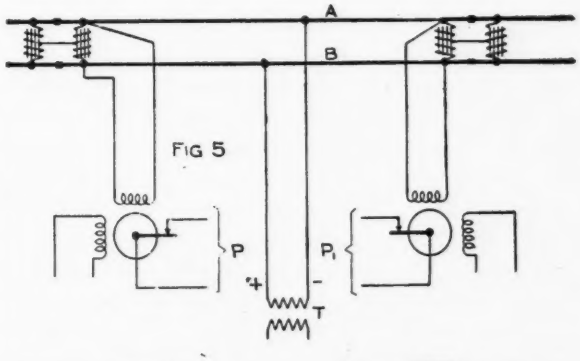


FIG 5

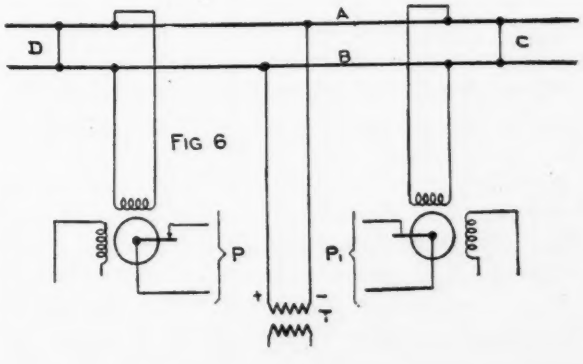


FIG 6

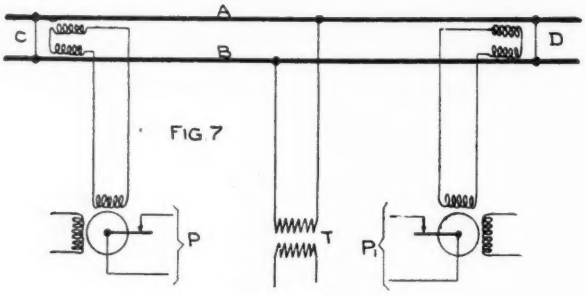


FIG 7

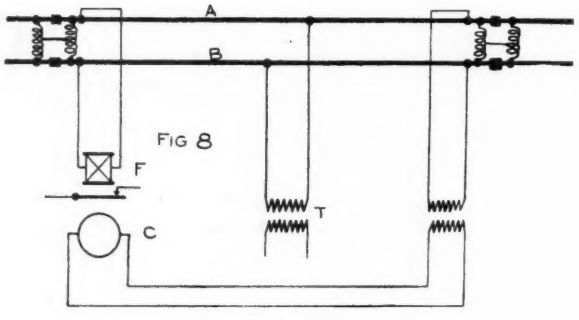


FIG 8

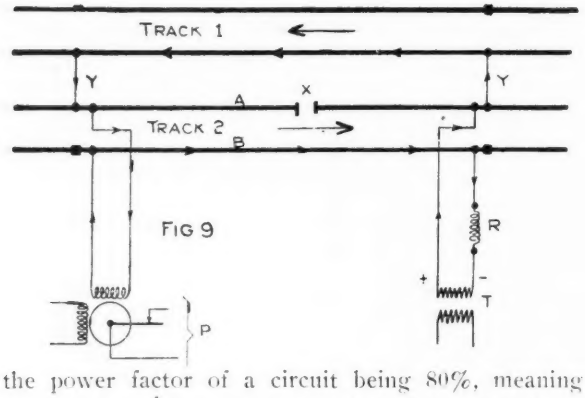


FIG 9

the power factor of a circuit being 80%, meaning thereby that the true energy is 80% of the volts times the amperes when current is sent through said circuit. The reason for the true energy being less than the apparent energy or volt amperes, is that the current lags behind the voltage and therefore, when the voltage is high the current is low and vice versa.

Coming again to the track circuit under consideration. The power factor of such a circuit is about 85%; hence the true energy delivered by the transformer is 85% of 135 volt amperes or about 115 watts.

Taking into consideration the loss in the transformer and the transmissin line and including the energy delivered to the local winding of the track relay, a track circuit of this type 1,600 feet long would require about 150 watts from the power house.

This may seem to you a very large amount of power in comparison with the very small amount taken by a steam road track circuit, but when it is remembered that it costs in the neighborhood of $10.00 per year for labor and material to keep the gravity batteries for a steam road track circuit going and further, when it is considered that power can be developed and delivered for from 1.5 to 2 cents per kilowatt hour and therefore the cost of power for a 1,600 foot track circuit of this kind is about $20.00 to $25.00 per year, the comparison does not look so bad.

Of course, if less unbalancing could be allowed, we could have more reactance in the bonds at the same cost and the power would be considerably reduced, or at considerably more expense we could produce bonds having a higher reactance with the same unbalancing but taking it all in all, the bonds now being employed seem to be about right on the basis that minimum total cost results when the interest on the investment equals the operating expenses of a given system.

If anything, the bonds are too large, as those familiar to the writer have never been known to overheat, even under maximum traffic conditions, so that from this standpoint smaller bonds could safely be used than those specified. This, however, is a matter that experience alone can demonstrate, as one cannot sit down and say that because a bond has such current capacity that therefore it will do for a given traffic, any more than it would be proper for an engineer laying out an industrial establishment to say that because he has 100 H. P. in motors for driving his machinery, he will make his generating plant 100 H. P. also.

As a matter of fact, all the motors never run at full load at the same time, as experience has shown and therefore certain percentages have been established for detrmining the sizes of generating plants for such purposes. It is something after this order that the size of bonds for Electric Traction purposes should be determined.

Track circuits of the type shown by Fig. 3 may be operated up to a length of about 2,000 ft. without undue energy consumption, .055 ohm reactance bonds being used with 100 lb. rail. For track circuits longer than this the centre fed circuit, Fig. 5, may be used and which with the same bonds and size of rail, may be made 6,000 feet long and over without undue energy consumption or the track voltage becoming too high and provided the Railroad Company will permit the intervals between cross bonds to be as great as this.

It is to be noted in this type of circuit that no bond is used across the rails at the transformer and when it is remembered that in the 1,600 ft. end fed track circuit (Fig. 3), the energy end bond C took 30 out of the total of 35 amperes, one can readily see what is the cause of so much energy consumption in an end fed track circuit and why it is possible to run such long centre fed track circuits.

It is further to be noted that Transformer T has nothing to do but feed the track circuit. This being the case, no resistance grid need be used, between transformer and track to prevent an excess current flowing with a train at that point. Since the transformer itself can be so designed that when an attempt

is made to draw an excess current from it, its voltage will drop and thus prevent such an occurrence.

The question may be asked if centre fed track circuits consume so little energy, why not use them under 2,000 ft The answer is that such circuits require an extra relay, an extra transformer and one or more wires through the block plus the proper share of common wire, since the signal must be controlled through both track relays. The cost of this apparatus capitalized would about offset the saving in energy. Of course, you understand, I am speaking in round numbers when I place the limit of an end fed track circuit of this type at 2,000 ft. since there are many conditions which would alter this. However, my statements will be found roughly correct.

To give you some idea of the relative power consumption of a centre fed as compared with an end fed track circuit, would state that for a length of 2,000 feet the end fed track circuit would take six to seven times the energy and for a 1,600-foot track circuit about four times.

In concluding my remarks on the two-rail type of track circuit employing iron core reactance bonds as shown by Figs. 3 and 5, your attention is called to the following resume:

1st. Track circuits of this type are especially adapted to heavy electric traction, or where the track circuits are very short and where broken rail protection is required. They may also be used on roads employing A. C. current for traction.

2nd. They are not well adapted for complicated track layouts, such as terminals, interlocking plants, etc., on account of their expense and the size of the apparatus which must be located at the track and the runs of heavy copper cable necessary.

3rd. They are very stable track circuits. That is, they will stand very leaky ballast conditions without perceptible effect on the relay.

4th. Broken rail protection is inherent in this type of track circuit.

5th. End fed track circuits may be used up to about 2,000 feet in length and centre fed up to 6,000 feet and over.

6th. Cross bonding between tracks can occur only at the ends of sections.

Coming now to the type of Two Rail Track Circuit employing Ironless reactance bonds as shown by Fig. 4.

The bonds, as their name suggests, have no iron about them except what is in the enclosing case and merely consist of a number of turns of heavy copper strip properly insulated.

There being no iron in the core, many more turns must be employed to give the necessary reactance and therefore the copper cost runs up much higher than in an iron core bond for the same current capacity. Therefore bonds of this type are commercially practical only for roads running light traffic.

However, as bonds of this type are not susceptible to unbalancing effects, as are the iron core bonds, they may be made of high reactance with the result that end fed track circuits as long as one and one-half miles may be used with a very moderate current consumption, and centre fed track circuits as long as three miles. In fact, the writer has in mind an 8,800-foot end fed track circuit of this type which has given uniformly excellent service for some years.

Referring again to Fig. 4, it will be noted that the bond (C) at the transformer end consists of a single coil connected across the rails in the usual manner but that at the relay end the bond (D) has two windings, one connected directly across the rails to serve as the return for the propulsion current, and the other in inductive relation thereto for operating the relay. The object of doing this is to prevent an excessive direct current flowing through the relay due to the drop caused by the passage of the propulsion current. This is not required at the energy end because the transformer is designed to withstand such direct current as may flow through it.

Track circuits of this kind employing ironless reactance bonds may be connected in all respects like Figs. 3 and 5. That is, adjacent track circuits may be connected by centre taps on adjacent bonds. When

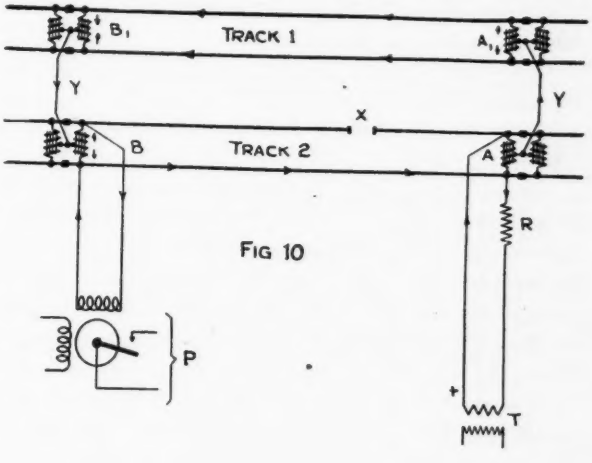


FIG 10

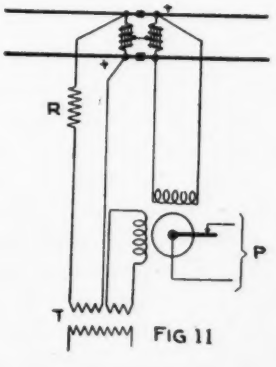


FIG 11

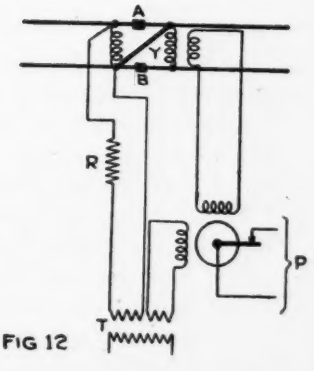


FIG 12

so arranged the secondary coil on bond D need not be used.

In track circuit as shown by Fig. 4, broken down joint protection is given regardless of the polarity of adjacent track circuits and will be explained later, whereas were the centre tap method used for connecting adjacent track ciruits, the proper polarities would have to be maintained.

In concluding my remarks on this type of track circuits, attention is called to the following points.

1st. This type of circuit is suitable for track circuits from one to three miles long where light electric traction exists, such, for example, as interurban work.

2nd. It is not subject to unbalancing troubles.

3rd. It is a very stable form of track circuit. As much so, if not more, than the type employing Iron Core reactance bonds.

4th. The continuous rails of each track may be cross bonded as often as desired.

5th. When adjacent track circuits are connected by centre taps on the bonds, broken rail protection is afforded on both rails.

In addition to the various types of track circuits thus far described, there are certain other types which are in use or have been tried experimentally, some of which are shown by Figs. 6, 7 and 8 and which I will briefly describe as follows:

Figs. 6 and 7 show track circuits in which the sections are limited by conductors C and D instead of the usual insulated rail joints energy being fed in at the centre.

In the circuit, Fig. 6, the relay leads are plugged into the rails at a point 10 to 15 feet from the limiting bonds C and D. The relay is operated by the drop produced when sufficient alternating signal current is caused to flow through the limiting bond and the short lengths of rail between said bond and the point where the relay leads are plugged into the rail.

The track winding of the relays is made of low resistance and relatively large current capacity so that they will operate on a very low voltage.

The track circuit, Fig. 7, is electrically similar to that shown by Fig. 6 except that the relays are operated from secondary track coils placed so as to be in close inductive relation to the signal current in the rails instead of by direct contact with the rails as shown in Fig. 6.

In both types of track circuits to secure strong operation of the relays, relatively heavy alternating currents must be sent down the rails with the result that on very long track circuits the voltage across the rails at the transformer will be very high.

Track circuits of this type have the advantage that there are no insulated joints or reactance bonds required and were this the only consideration there would be a very distinct advantage in their use. But the disadvantages more than outweigh the advantages, in fact, to such an extent that this type of track circuit cannot be considered practical for the following reasons:

1st. Centre feeding must be always used regardless of the length of the track circuit. Hence the need of an extra transformer and track relay, together with neecssary wires running to the block.

2. By far the most important objection is the bad shunting characteristics possessed by this type of track circuit. As developed to date, in either type of track circuit, a light car can stand over one of the limiting cross bonds C or D with the likelihood that both relays would pick up and give a clear signal. This will be evident when it is remembered that to shunt the track circuit with a car at this point the resistance through the wheels should be less than the resistance of a few feet of rail plus that of the low resistance cross bond C or D. With a very heavy engine or car and with the track rails and wheels bright, the relays will probably hold down under this condition. But with a light car, and especially if the rails are dirty or the wheels in the same condition, the relays are likely to pick up.

When, however, there are a number of cars, as in a train the action of this type of track circuit is very satisfactory and it is a question for the railroads to decide whether or not they wish to use it.

I do not wish to be understood as saying that this type of track circuit cannot be developed to a point where it will be perfectly safe under all conditions as it is unsafe to make predictions in these times when so many revolutionary things are being accomplished, but at the present time it appears to be unsafe under the conditions mentioned above; namely with a light car standing over the cross bond.

Referring now to the type of track circuit shown by Fig. 8:

In this form of track circuit, energy is fed in at the centre, a single relay being used, of the double wound type. The field F of the relay is fed from one end of the track circuit and the armature C from the other end of the track circuit through the medium of a small step-up transformer T1. Track circuits of this type have the advantage that only one relay is required and the signal circuits do not have to be carried through the block. It is of course necessary, however, to carry the wires for the relay armature through the block.

This type of circuit is in use on the West Jersey & Sea Shore Electric road.

Having thus far directed your attention mainly to track circuits for direct current electric roads, I desire now to consider them with reference to roads employing alternating current propulsion.

As stated before it is necessary in such cases to employ a signaling frequency distinctively different from that of the propulsion current and to use relays responsive thereto but unresponsive to the propulsion frequency.

Furthermore cases have arisen where in addition

to the A. C. propulsion current foreign direct urrents were also present in large quantities so that it became necessary to provide relays immune to both kinds of current.

With regard to the type of track circuit to employ I would state that it is desirable to use those having ballanced bonds as in Figs. 3 or 5.

In A. C. Traction the propulsion voltage employed being very high the current is proportionately small and therefore the bonds can be made very much smaller with a consequently large reduction in cost. For example bonds for a 11,000 volt A. C. road need be only about one eighteenth the carrying capacity of the bonds required for a 600 volt D. C. road for the same traffic, or assuming 1,250,000 circular mill bonds to be necessary for a given traffic, on a 600 volt D. C. road then No. 2 B. & S. wire could be used for a 11,000 volt A. C. road for the same heating.

Aside from the foregoing observations and the fact that track circuits for A. C. roads take somewhat more power than for D. C. roads the remarks thus far made with reference to the two rail track circuits, for D. C. roads, employing Iron core bonds apply in a general way to A. C. roads also.

Before concluding my remarks on A. C. track circuits I wish to mention their use in connection with steam roads.

As formerly stated A. C. track circuits are a sure cure for the effects of foreign currents and should be used on steam roads where such currents are prevalent.

The type of track circuit used would be practically the same as that shown by figure 1 except that no provision need be made as in the case of electric roads to prevent the heating of the relay or saturation of the transformer by traction current and on this account the energy per track circuit is a minimum. For example a 6,000 ft. track circuit, end fed, can be operated on 15 to 20 watts. End fed track circuits of this type as long as 8,000 feet, and centre fed track circuits up to 3 miles long will operate satisfactorily using the ordinary bond wires employed in steam roads track circuits.

In speaking of Iron bond wires it may be of interest to you to know that they more than anything else limit the lengths to which A. C. track circuits on steam roads may be operated. If copper bonds were used much longer track circuits could be operated.

It is of course obvious that no reactance bonds are needed on steam roads.

It is also interesting to know that where electrifiation in the future is contemplated if A. C. apparatus is installed for present steam operation it can be continued in use under electric operation by the addition of reactance bonds and by making some slight changes in the circuits.

Having described the various types of track circuits commonly employed on electric traction lines, both of the one rail and two rail type, I wish to direct your attention to the methods whereby a broken down insulated joint is detected and broken rails indicated.

Taking first the matter of broken rails: In steam road track circuits, where the rails of adjacent blocks are not connected to each other nor to parallel tracks, as in the case of electric roads broken rail protection is given in the simplest possible manner, provided of course, that the relay is not receiving energy from the battery in the adjacent track circuits by reason of defective insulated joints. Barring this, the opening of the electric circuits by the breaking of a rail will of course cause the relay to open.

In electric traction, however, a very different set of conditions exists on account of the fact that "cross bonding" has to be employed so that the traction currents coming from a given car or train can distribute as quickly as possible to all rails and thus return to the power house with the least loss. It can readily be seen that, were there no such connection between the tracks of a given railroad, the current from a train would have to traverse the entire distance to the power house on one set of rails only, except such as might leak through the ground. This would of course result in a very great drop of potential, especialy with heavy trains and would be felt to a very marked degree. The coal pile, to say nothing of the slow speeds which would result and the fluctuations of the lights in the cars when the train is started and stopped. It therefore becomes essential to use cross bonds.

This being the case, if a rail breaks as at X, Fig. 9, the current to the relay is not interrupted, but can flow, as shown, from transformer positive through cross bond Y, down one rail of track 1, through the other cross bond Y, through the relay and back rail B to the transformer. It will thus be seen that with a broken rail as at X, the relay will not open.

Broken rail protection is of course given on the signal rails, B, that is the one which is given up for signaling purposes, but is not and cannot be given on the traction rail in single rail track circuits except at a great expense. It is therefore in the judgment of the writer not wise to use this type of track circuit where unlimited or limited speeds occur.

In Fig. 10, however, is shown a type of track circuit in which broken rail protection is inherent.

This, you will note, is the iron core bond type of track circuit, illustrated in Fig. 3.

Assume the tracks to be cross-bonded at Y and Y1. If now, one of the rails breaks as at X, the current from transformer T, instead of flowing to the relay via the broken rail, will take the following path:—Through one half of bond A, the cross bond Y1, through both rails of track 1 and both halves of reactance bonds A1 and B1 in multiple, through cross bond Y, through one half of bond B and

through the unbroken rail of track 2 back to the transformer.

It will therefore be seen that the bypass around the broken rail starts at the middle point of bond A and ends at the middle of bond B and that therefore the voltage tending to send current through this by pass is only half of the normal voltage across the rails at the energy end.

Furthermore the current which flows through this by pass only goes through one half of the relay bond B and therefore produces at the relay terminals one half the voltage which it would produce were it to pass through the whole bond.

If the track circuits shown by Fig. 10 were 1,600 feet long and the rails 100 lbs. steel the resistance of the by pass from the centre point bond A through half of bond B and back the unbroken rail to the transformer would be about 65% of the normal path from one terminal of bond A down the rail now shown broken, through bond B and back to the transformer.

By combining the above facts it will be seen that the voltage across the relay with a broken rail will be approximately 40% of normal. Had three tracks been cross bonded with the one in question this voltage would have been about 45% of normal.

Furthermore, returning to the two tracks illustrated had cross bond Y been moved down the length of one track section thus making the length of the by pass very much greater the voltage at the relay they would have been about 25% of normal with a break at X.

To make a long story short with a broken rail the voltage delivered at the relay will be less than 50% of normal even with the least by-pass resistance possible and will be less than this with long track circuits and with less track cross bonded to each other.

Furthermore, if the tracks are cross bonded at every other location a much greater reduction in voltage at the relay will result than otherwise.

Inasmuch as A. C. relays can be adjusted for a very high dropaway it becomes a comparatively simple mater to arrange them so that they will operate satisfactorily with the rails intact, but will open positively if the rail breaks.

Coming now to the matter of detecting a broken down insulated joint. Your attention is directed to Fig. 11 which shows the adjacent ends of the two track circuits, it will be noted that the polarity of adjacent rails is opposite (the negative polarity signs have been omitted in error).

With the type of relay shown, that is with one winding fed from the track and other fed from a local source of energy, the relay will operate in one direction with a given polarity and will operate in the other direction if the polarity is reversed. Therefore, if either of the insulated joints should break down, the energy from transformer T passing across the broken down insulation, and back through the centre connection between the bonds, would cause the relay to open positively and thus set the proper signals at stop and caution. With relays which take all their energy from the track this will not hold good.

Referring now to the circuit shown in Fig. 12, this will be recognized as the type of track circuit illustrated in Fig. 4. By means of the diagonal cross bond Y if joint A breaks down, the transformer will be short circuited and if joint B breaks down the relay will be short circuited. Thus the diagonal cross-bond Y acts as a shield between the two track circuits.

There are other methods of giving the indication of a broken down insulated joint, or preventing the giving of a false clear signal due to such contingency, but the methods as above described indicate in general how this can be effected.

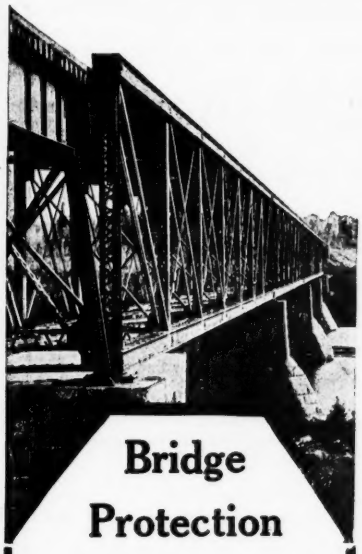
Having now gone quite fully into the matter of track circuits in general, let us discuss some of the devices involved.

Taking first the track relay. There are two general types on the market, namely those in which all of the energy for operating them is taken from the track circuit and those in which the energy for operating them is taken partly from the track circuit and partly from a local source. The latter type being the one illustrated in connection with the various track circuits described. With the exception of that shown in Fig. 8 which is a double wound relay, both members of which are fed from the track circuit.

The relays which take all of their energy from the track circuit have the advantage that they are somewhat less complicated. That is, it is not necessary to supply local energy for their operation. The supplying of this energy is, however, not a serious matter when it is remembered that energy will usually be available from transformers existing for other purposes in the vicinity of the relay. For example, it will be noted in Fig. 1 that the same transformer feeds both the local winding of track relay and also delivers energy to the track circuit proper.

These relays have the dis-advantage that they require a great deal more energy from the track circuit than do the double wound type and when it is remembered that the track circuit is, at best, an exceedingly inefficient system for the transmission of power, it is evident that more effect can be developed with the same amount of energy by sending a small amount of energy over the track circuit for operating the relay and supplying the bulk of the energy locally.

The double wound relays, that is, those which take energy both from the tack circuits and locally, have the advantage that they will operate in one direction from one polarity and in the opposite direction from another polarity. This feature makes this type of relay very effective when it comes to indicating a broken down insulated joint as shown by Fig. 11.



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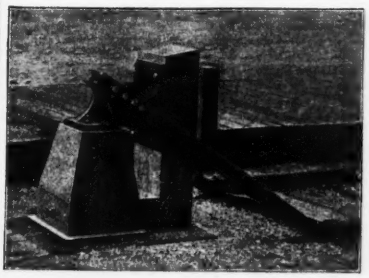

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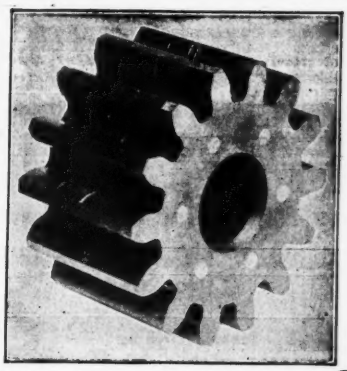

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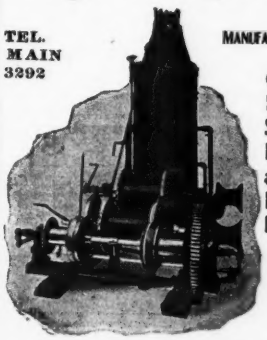

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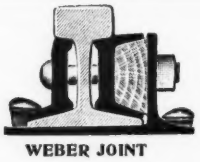

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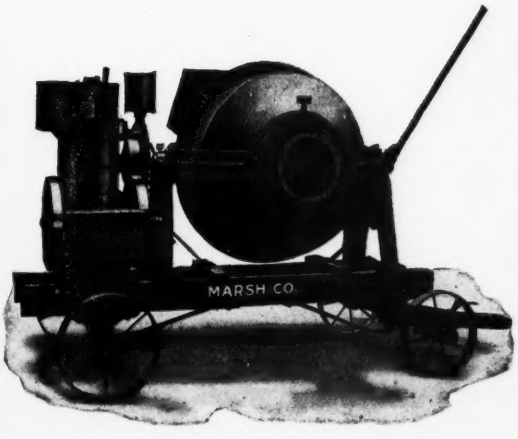

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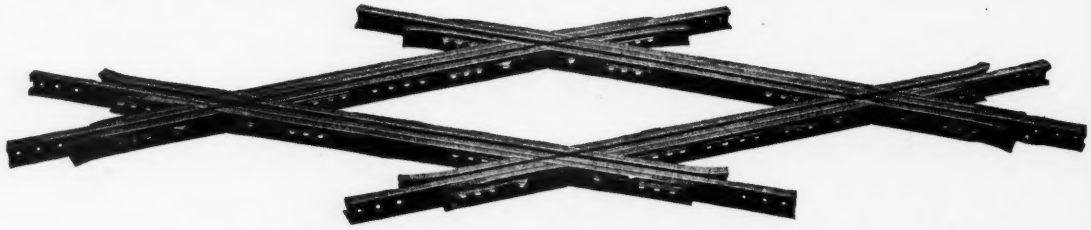

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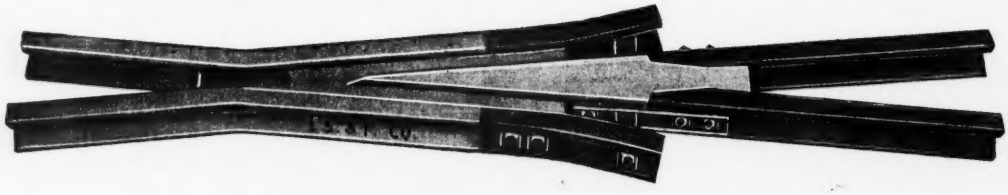

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